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THE STRUCTURE OF LOGIC AND ITS RELATION TO OTHER SYSTEMS[1]

There are, in general, three types of logical theory: (1) The view which treats logic as formal and at the same time as concerned with the actual modes of right thinking. Traditional logic is of this type. (2) The view which regards logic as concerned with the actual processes of right thinking, and *for that reason* repudiates the formalistic conception of logic as inadequate. The so-called "modern logic" illustrates this type. (3) The view which treats logic as formal and renounces all attempts to portray the actual psychological processes which lead to the discovery of truth. Recent mathematical logic—what Mr. Spaulding has called the "new logic"—belongs to this type.

The critical comparison of these three theories is an important and interesting topic, but it can not be accomplished in a twenty-minute paper. Instead, we shall here take the third type of view as our point of departure, and proceed to certain consequences of it which concern the application of logic to more general problems.

From the present point of view, then, logic does not have to do with the modes of reasoning, either actual or ideal, but only with *criteria* of validity in inference—or, viewed in another way, with the fundamental types of order. It is related to our thought processes somewhat as the tests of an artistic masterpiece might be related to the psychology of genius. We throw our ideas into the deductive forms for the sake of testing their consistency; we seldom do or can make use of them in the actual constructive process of thinking.

No criticism is here implied of any investigation of those thought-processes which normally lead to correct results. When the coincidence of forms of thought with modes of logic is given up, the portrayal of the normal or typical successful thought-process is no less important for being separated from logic. The "new" logicians can recognize the significance of this problem, set by the "modern" logicians, even if the "modern" logicians refuse to return the compliment. The insistence is only upon the separation of questions of psychology from questions of validity.

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[1] Read, with omissions, at the twentieth meeting of the American Philosophical Association, at Columbia University, Dec. 29, 1920.

Again, the new logic regards the deductive system not as a method of proving truth so much as a method of presenting results and establishing relations. The most successful logical structures which thought has produced are the systems of deductive mathematics. The illusion that such systems are demonstrations of complex facts from simple and self-evident axioms was dispelled by non-Euclidean geometry and investigations of the infinite. In modern developments, the selection of primitive propositions is governed solely by their deductive power and simplicity and by the system which is to be developed. Such postulates are no more evident or certain than theorems. Frequently they are less so. *Principia Mathematica* triumphantly demonstrates on page 83 of volume II that $m + n = n + m$, but some of its postulates are fairly dubious (the "axiom of reducibility" for example). It is as much the assumptions which are verified by the theorems as the reverse. Or, more accurately, it is the internal order of the system and its *general* conformity to fact which helps to verify any particular proposition which might otherwise be in doubt. Such verification—as it is important to note—is always partial and inductive, since it is possible that another deductive system, with slightly different and equally acceptable assumptions, may contain all the propositions observed to conform to fact and exclude those which are in doubt. The more or less deductive developments of "Newtonian" and relativity physical theory may serve as an illustration.

It is an important consequence of this view that the attempt to establish incontrovertible truth by deductive procedures is nugatory. The traditional rationalistic conception that metaphysical first principles can be shown to be logically necessary, or that what is logically prior is more certain or self-evident, is a conception to which the actual structure of logical systems lends no support. In genuinely rigorous deductive systems, "logically prior" means only "deductively more powerful" or "simpler." The supposed necessity of presuppositions most frequently turns out to be nothing more significant than lack of imagination and ingenuity. And in the remaining cases, that which is presupposed is not, by that fact, proved true. The plurality of possible beginnings for the same system, and the plurality of equally cogent systems which may contain the *same* body of already verified propositions but differ in *what else* they include, dispel the notion of indispensability or peculiar importance in that which is logically prior.

An exception to these strictures will probably be urged for the fundamental principles of logic itself. The laws of logic—it will be said—are not only presupposed by science and rational investigation in general, but their necessary truth is further attested by the fact that they are implied by the very attempt to negate them. To deny them is to reaffirm them. Here is a veritable foundation stone for the rationalistic procedure. Here is the indubitable basis upon which we can build anew the entire structure of exact science, and perhaps eventually of philosophy, assuming only that which no rational mind can deny. Is not this what the most notable examples of the new logic themselves make evident?

But the laws of logic are, in fact, no exception. That the denial of a proposition leads to its reaffirmation, by no means establishes its truth. This foundation stone will not bear its own weight, to say nothing of the proposed superstructure. To see that this is so, we must first examine the nature of "reaffirmation through denial." Whoever asserts a self-contradictory proposition does not in one and the same breath affirm and deny the content of his assertion. He affirms it in fact; he denies it by implication only. Or to put it otherwise: he affirms it, and the question whether he also denies it is the question of what his assertion implies. Now the question of what an assertion implies, is precisely a question of logic. The content of logic is the principles of inference. Whoever, then, denies a principle of logic, may either draw his own inferences according to the principle he denies, or he may consistently avoid that principle in deriving his conclusions. If one deny a principle of inference, but inadvertently reintroduce it in drawing conclusions from his statement, he will indeed find that he has contradicted himself and admitted what originally he denied. But if he denies a principle of inference and consistently reasons in accordance with his own statement, he need incur no self-contradiction whatever.

It is a fact that for one who stands *within* a given system of logic, the denial of one of its principles will imply the principle itself. But this signifies nothing more profound than the fact that deductions *in* logic are inevitably circular.[2] In deducing our theorems of logic, we must make use of the very principles which the deduction is supposed to demonstrate. If, then, I use "bad" logical premises but "good" logical reasoning, I shall contradict myself, quite as surely as if I use two premises which are mutually inconsistent. Perhaps an example here will be of assistance. Take the law of contradiction in the form, "That x is A and x is not A, is false." Its contradictory will be, "x is A and x is not A." Let us take this last statement as a premise and draw the inferences from it.

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[2] Omitting from consideration the development of logic, as a purely abstract system, by the "operational" instead of the "postulatory" method. These omitted considerations serve to strengthen, not to weaken, what we here set forth.

(1) "*x* is *A* and *x* is not *A*" implies its latter half, "*x* is not *A*."

(2) "*x* is not *A*" implies "It is false that *x* is *A*."

(3) "It is false that *x* is *A*" implies "That *x* is *A* and *x* is not *A*, is false." (Just as "'Today is Monday' is false" implies "That today is Monday and it is raining, is false.") Thus from the denial of the law of contradiction, we have deduced the law of contradiction itself. But we have done so only because, though denying it in the premise, we have reintroduced it in step (2) of the reasoning. If we had, consistently with the premise, refused to take step (2), we should never have got any such conclusion.

Every good or correct logic, then, will be such that its principles are undeniable without contradiction; the denial of any one of them leads to formal inconsistency. But this is true only because so long as we remain *within* our system of logic, we shall use the very principle in question in drawing inferences from the denial of it, and thus beg the question of its truth.

A *good* logic *must* be circular. But what should lead anyone to suppose that this character belongs exclusively to systems of *good* logic? Apparently those who set store by the "reaffirmation through denial" have committed the fallacy of illicit conversion: they have reasoned; "A logic whose principles are true will give their reaffirmation through denial. Therefore, whatever principles meet this test must be true."

All logic and pseudo-logic, is similarly circular. A little ingenuity suffices to construct a bad logic in which, reasoning badly according to our bad principles, we always get consistently bad results. And if we deny one of these principles, still by sticking to our bad method of reasoning, we can reaffirm the bad principle in conclusion.[3] Since a bad logic, whose principles are false, may still be such that the denial of any one of these principles will lead to its reaffirmation, it follows that the test of "reaffirmation through denial" does not, in logic, prove the truth of the principle thus reaffirmed.

[3] One family of such systems—consistent in their own terms, and such that the denial of any principle lends to its reaffirmation as a consequence—is determined by the presence in the system of the proposition

$$q < [p < (p < q)]$$

where p, q, *etc.* are propositions, and $p < q$ represents "p implies q," or "if p is asserted, q may be asserted." This proposition allows of two distinct meanings of $p < q$, neither of which coincides with the usual one; and the properties of this relation may be further specified in a variety of ways. *Some* of the systems in this family might be regarded as "good" logic, but most of them are "bad." Such a "bad" logic may be developed logistically from the following formal postulates:

It should be added, to avoid misunderstanding, that in spite of what has just been said, the test of self-criticism or circularity is a valuable test of any deductive development of logic. That the principles proved are precisely the principles used in the demonstration of them, is here a matter for congratulation. That the method of our proof coincides with the result of it, is a test of both method and result. It is not a test of truth, however; it is a test of formal or methodological consistency. The error of taking self-criticism to be a test of logical *truth* lies in overlooking the fact that a thoroughly false logic may still possess this merely methodological consistency.

One further bit of explanation seems required also. We do not mean to say that there are no necessary propositions. Whoever takes a given logic to be true will find its principles undeniable without contradiction (*i.e.*, in his logic) and therefore necessary. Some logic is true, and hence some logical principles are necessary. The point is simply that the truths of logic are not *proved* by any such procedure—since, as proof, it always begs the question. The basic necessities can not be proved but only recognized or assumed —and they are assumed at the risk of error.

This disposes of "reaffirmation through denial" as a test of logical truth sufficient to establish first premises. But it may still be questioned whether the test has not valuable applications outside logic altogether. One may admit its insufficiency to establish the truth of a logical principle, should that logical principle really be in doubt; but one may still urge that, once the principles of logic have been recognized and accepted, this test of reaffirmation through denial becomes applicable outside the field of logic, and that, furthermore, the use of the test outside logic does not involve any circularity.

The answer is that there are, in fact, necessary and self-contradictory propositions which are not of logical import, and that the test in question would be entirely legitimate and final here if it were not for the unfortunate circumstance that whatever is taken

A. $-(-p) = p$ (Def. of $-p$, the denial of p)
B. $-(p < -p)$
C. $(p < q) < (-q < -p)$
D. $[p < (q < r)] < [q < (p < r)]$
E. $(q < r) < [(p < q) < (p < r)]$
F. $(p < q) < (-p < -q)$

Postulate F is obviously false as a general law of implication. It is interesting that postulate B seems to exclude the possibility that any proposition should lead to its own denial as a consequence, yet if P be any principle of the system, we can prove that $-P < (-P < P)$. Hence the assertion of $-P$ leads to the assertion $(-P < P)$.

to be thus established will be found in each instance either to have been already assumed or not to be really demonstrated. Any case in which this test is supposedly used to establish truth should be subject to close scrutiny; there is always a colored gentleman in the woodpile. Indeed, the fallacies involved in current examples of the reaffirmed-through-denial and the self-contradictory are so simple as hardly to need pointing out.

For example, the fallacy of arguing from the undeniable existence of thinking to the self which does the thinking vitiates Descartes's use of the "I think." But quite apart from that, the man who should assert "I am not thinking," so far from contradicting himself, would give the best possible evidence of the truth of his statement. The proposition, "I am not thinking," does not imply, "I am thinking." It may be that the attitude of will which we suppose to underlie the making of *any* assertion is such as to be incompatible with the admission, "I am not thinking," so that we may be sure that whoever could make such a statement would find himself at cross purposes. But the reason for this is contained neither in the proposition nor in any implication of it. There is here no logical inconsistency whatever.

Again, it is said that the statement "There are no propositions" is self-contradictory—because it is itself a proposition. So far from being self-contradictory, it is quite plausible. There are important considerations which point to the conclusion that the idea of a proposition is one which can never be exemplified in human speech or thought—that "proposition" is a sort of ideal like the absolute good. Also, we may note in passing that Mr. Russell, who admits the existence of propositions, would deny that "There are no propositions" is itself a proposition. But suppose we forget all this, and agree that it is a proposition. Still it is not self-contradictory. It *is* a proposition—we agree—but it neither states nor implies that it is a proposition. A proposition does not assert its own existence any more than a bar of pig-iron asserts its own existence. What a proposition asserts is its *content.* Moreover, even if it *did* imply its own existence, it would not serve as an example of "reaffirmation through denial" proving new truth. For whoever assumes that "There are no propositions" is itself a proposition, has assumed already that there are propositions and that this one is false. But if one does *not* assume that "There are no propositions" is itself a proposition, then its implication of its own existence would not be the implication that *a proposition* exists, and no contradiction would develop.

These two examples are typical. There *are* necessary propositions, and some of them can be proved—from other necessary propositions as premises—but they can not be proved by being implied by their own denial. Without qualification, nothing can be shown to be so implied unless it is already assumed. The use of reaffirmation through denial is never legitimate as demonstration of new truth, though it *is* legitimate, and frequently valuable, as a means of pointing out inconsistency of assumption.

Questions of logical priority are often confused by use of the term "presuppose." This word has no single meaning, but it is commonly used to designate what is logically prior with the added thought that it is also necessary. Correctly speaking, what is logically prior to X, will imply X, but it will not, in general, be implied by X. In the language of mathematics, if A is logically prior to B, then A must be a sufficient condition of B or at least one of a sufficient set of conditions; but "sufficient condition" must not be confused with "necessary condition."

Frequently, there is a concealed argument from the particular to the general in the appeal to "presupposition." Physics presupposes mathematics in the sense that physics can not be developed without mathematics, while mathematics contains no necessary reference to physics. And in the same sense all the special sciences presuppose logic. But if what is presupposed in this sense be regarded as thereby established or proved necessary, the fallacy involved is easily detected. If I assert that two feet and two feet are four feet, I do not thereby commit myself to the proposition that $2+2=4$. It is required only that this should be true of linear measure. Gases under pressure or living organisms might—for all that is here in question—be governed by very different mathematical laws. The particular fact does not even require that there should be *any* general laws of mathematics. There can be little doubt that this fallacy has played its part in the traditional *a priori*. Presuppositions, so called, are always general in their import. The facts that presuppose them are particulars. Now A is not a necessary condition of B unless "A is false" implies "B is is false," *i.e.*, unless B implies A. *No general principle is a necessary condition of any particular fact or assertion unless the particular fact or assertion implies the general principle.*[4] And even if this should be the case, it would be the particular and not the general which was, so far, logically prior and the original premise.

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[4] If I am not mistaken, there is such a class of general principles which are genuinely implied by all subsumed particulars—the laws of logic. This depends, however, upon a meaning of "implies" which can not here be taken for granted. Further, the discussion of this class of "necessary presuppositions" would alter nothing which precedes, since these presuppositions can not be *proved* from the fact that they are thus universally implied. The reason is obvious: they would have to be first assumed in order to provide the demonstration itself. They are "presupposed" in exactly the same sense that they are "necessary"—that is, only in the system in which they are *first assumed.*

If we avoid this fallacy and take "*A* presupposes *B*" to mean "*A* is necessary condition of *B*," *i.e.*, "*B* implies *A*," then we should be so cluttered up with presuppositions that the fine glamour of the word would be wholly lost. Presuppositions would be truly necessary conditions—that is, relatively necessary—but instead of being first facts they would be last facts, or later facts, and would ordinarily rest upon all sorts of assumptions. Their necessity would ordinarily be whatever necessity had already been established for the fact which presupposed them—that and nothing more.

There are two further meanings of "presupposition"[5]—two which differ from the previous ones by affording some ground for the metaphysical respect in which presuppositions have been held. "Presupposition" may be taken in the literal meaning of "earlier assumption." Mathematics truly stands to the laws of physics in this relation, and logic to all the special sciences. So understood, a presupposition is logically prior. But the idea of necessity is given up. Where the body of facts which such a presupposition implies is considerable and well established, and there are no implications of it which are known to be false, the presupposition gains that kind of verification which particulars can give to general principles—that is, the partial and inductive verification of it as an original hypothesis.

The one remaining meaning which has been referred to attaches to "presupposition" a significance which is psychological rather than logical. It may be maintained that certain general laws are required, not in the sense of being logically inescapable, but in the sense that they are *necessarily assumed* by every rational mind. It seems likely that historical rationalism has regarded the fundamental necessities as psychological in precisely this sense. If there are universal presuppositions in this sense, their necessity is simply the necessity which a rational being recognizes in the criteria of his own rationality. So viewed, the crux of the question concerns the existence or non-existence of such universality of rational intent.

The discussion of this question is not strictly required for our point, because what is necessarily assumed is confessedly such that its necessity is incapable of demonstration. But it may be of value to indicate briefly a point of view which is compatible with what precedes, and to suggest some of the reasons for it.

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[5] I omit from consideration a meaning which Mr. Spaulding has given—"*p* presupposes *q* when '*p* implies *q*' implies '*q* implies *p*' "—because I have never been able to exemplify it. One comment may be made: if '*p* implies *q*' implies '*q* implies *p*', then *p* and *q* are equivalent propositions, and hence *equally* necessary.

If there are any such universal principles of rational activity, we should certainly expect to find them exemplified in logic, since inference is the very archetype and exemplar of rational action in general. If there is any universality of rational intent, it will most clearly exhibit itself in a common logical sense.

Now whoever enters a discussion, pragmatically assumes that the logical sense of those engaged is the same with his. The pursuit of common enterprises, regarded as rational, rests at bottom upon a similar assumption. But in making this assumption—as we are frequently aware—we take a certain risk. In the interest of our rational enterprise we must take this risk. The principles of rationality—in logic as well as in ethics, jurisprudence, and politics—are not empirical facts but social demands. They are ideals; and ideals are things which do not exist as empirical facts. They do not exist even as universality of intent. The only common ideal is the ideal of unanimity—the demand of each that all shall agree with him. And this is as true in logic as in other matters. The facts of social life evidence a fairly general unanimity about the criteria of valid inference. But precisely where we should hope to find this unanimity complete—that is, amongst students of logic—it is, in fact, most notably and lamentably absent. The ideal of a universal logical sense is one strongly demanded by its importance to all social enterprises, and is more closely approximated in fact than most of our ideals. But sticking to facts, in the spirit of facts, we are obliged to admit that it does not completely exist and probably never will. It is easy to beg the question by defining "rationality" in one's own terms. But that can lead only to the familiar conclusion, "All the world is strange save thee and me—and thee's a little strange." With respect to ideals, we all of us stand in the ego-centric predicament; we can only assert our own and hope for agreement.

The whole development of the last quarter century goes to enforce the fact that no deductive system, logic itself included, can justly claim to be demonstration of certain truth from indispensable first principles. That is not what a deductive system is. Instead, as has been said, it is simply the orderly exhibition of certain important relations *amongst* facts or propositions. Whatever verification it affords extends quite as much and quite as simply to premises or assumptions as to conclusions. Such verification can never be complete or final except for those who are already determined to accept what the system sets forth as absolute truth.

It may seem to some that what the preceding discussion has chiefly demonstrated is the unimportance of deduction in general and the new logic in particular. Such a conclusion would be hasty. What the new logic is, in fact, capable of revealing is the existence of a new method for philosophy—or a new significance for the old deductive procedure—which has not yet been sufficiently recognized and exploited. It offers the deductive procedure, *not as a method of proof but a method of analysis.* Instead of taking the field of arithmetic, or of logic, *etc.,* as one in which indispensable premises are to lead to previously uncertain or undiscovered conclusions by a process of demonstration, it takes the generally accepted facts of arithmetic, or of logic, as a problem for analysis and orderly arrangement. In the process of making such an analysis and reconstructing our facts upon the basis of its results, we may—and most frequently do—come upon previously unsuspected facts or principles which are required by those more commonly recognized. And we may also discover reasons for discarding some conceptions previously accepted. But in general we accept the results of previous experience; the need is not so much to substantiate as to understand those results. For example, long before Dedekind and Cantor, it was sufficiently clear that the *use* of irrationals by mathematicians was a valid one. And the propositions stating their properties in use and their merely functional relations to other numbers were fairly well established. What was *not* clear was the *nature* of the irrationals. The problem was, as Dedekind's title puts it, "*Was sind und was sollen die Zahlen?* "

Similarly, the point of *Principia Mathematica* is not to prove that $m + n = n + m$ and $2 \times 2 = 4$, but to discover the nature of the various types of numbers, to indicate by its orderly development their relation to the more general categories of logic, to investigate the structure of the field of the various mathematical relations, to segregate those propositions which require more than purely logical assumptions, and to state those assumptions most simply and precisely.

Mr. Whitehead's recent book, *Principles of Natural Knowledge,* extends this procedure to the field of fundamental physical concepts. Although this development does not have the character of formal deduction, yet whoever reads it with care and compares it with the earlier study, *Mathematical Concepts of the Physical World,* will discover in it another exemplification of this method of deductive analysis. Here too, we have no *demonstration* of the facts of nature, but an analysis of the real meanings of such familiar terms as "moment," "duration," "point," "motion," "location," "coexistent," and "sequent." The point is not in the corroboration of proximate physical facts. So viewed, the book might amount to the proof that one and one make two in the physical world, that there are events and things, that the horse can run and the cat can really see. Its significance lies rather in that combination of insight and ingenuity with which proximate facts are analyzed, and the fundamental categories of physical science and our common sense dealings with the external world are cleared of confusion and connected in an orderly way. By such analysis, Mr. Whitehead provides a reasonable basis for accepted fact, but a basis which still is to be regarded as verified by its logical consequences rather than as verifying such consequences.

Whenever our knowledge of a body of facts approaches that completeness which makes it possible, the deductive development of those facts both serves to present them in the most economical way and provides the best possible understanding of their nature. It is by their orderly connection and their common derivation from a few simple ideas that *explanation* of them is afforded. The claim of uniqueness or exclusive truth for such explanation is commonly unwarranted. The same facts may admit of various explanations, from different points of view, *i.e.*, based upon different fundamental categories.

The use of this method has been coupled, most frequently, with a realistic philosophy. But it does not require the more general realistic position. It dictates no metaphysics, and comports also with idealism or pragmatism. The prominence which it gives to such criteria as simplicity and sufficiency, and the emphasis upon plurality of possible developments, are suggestive of pragmatism. The part played by internal consistency, and the verification of particulars through their relation to a systematic whole, emphasize conceptions which are prominent in idealism. It can even be claimed, of course, that the significance here given to the deductive system is essentially the same with that of historic idealism—that the acceptance of the facts of science and common experience and the discovery of more fundamental truths by making of these a problem in explanation, is exactly what Kant and his successors accomplished. The question how far such a claim is warranted, need not here concern us. It is complicated by the fact that the so-called deductions of the post-Kantians are formally defective, that idealism has usually insisted upon a psychological conception of logic, and by the occurrence in some idealistic arguments of the fallacies of presupposition which have been mentioned. Our only concern will be to point out that the claim of indispensability for a single set of first principles, or of exclusive truth for one method of analysis—the idea of the traditional *a priori*—is a claim which finds no place in the newer method and no justification in the logic which it applies.

To be sure, it is reasonable to suppose that as deductive analysis conquers successively larger and more varied fields of fact and brings these special fields into consonance by explanations of a higher order, the number of possible modes of development will be restricted. Perhaps finally, when human wisdom shall be summed up in an all-embracing and systematic deduction of everything, only one such analysis will be found possible and adequate. But an eventuality so remote does not warrant serious consideration.

It is just in the notion that the most general questions are presently capable of unique solution by a deductive procedure that traditional rationalism commits its glaring error. The fact is, of course, that the method is more applicable to subordinate questions than to such general problems. It is only when our knowledge of proximate facts becomes fairly comprehensive, detailed, and exact, that deductive analysis is capable of rendering valuable service. But it is also just to remark that it is precisely where no such procedure is applicable that the results of philosophic investigation are least subject to logical criteria and, consequently, most liable to error. The most general problems of philosophy are a field for speculation rather than proof. Yet even here, the mental habit which this method enforces—the search for explanation through analysis and open-minded consideration of alternative possibilities—has a value which should not be disregarded.

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THE ESTHETIC HERESY

THE basis of life is natural and hence, or at least at the same time, irrational. The basis I mean quite literally. That is we grow out of a subhuman, subrational matrix, and we are composed of impulses, instincts—whatever they are to be called—which simply are there and work, one of them being that irrational element of our makeup that we call reason—say the instinct of reason. It is the development of this that shows us that not all of our impulses can be gratified at will, or rather as they make themselves felt, as they just occur. For on the one hand they are seen to conflict with each other; and on the other hand our powers of representation put before us gradually a series of ideas that we hold together in the end as ideals—finished-off representations in